201-16048

HIGH PRODUCTION VOLUME (HPV)

CHALLENGE PROGRAM

FINAL SUBMISSION

For

PETROLEUM ADDITIVE ALKARYL SULFONATE CATEGORY

Prepared by

The American Chemistry Council
Petroleum Additives Panel
Health, Environmental, and Regulatory Task Group

October 2005

List of Member Companies in the Health, Environmental, and Regulatory Task Group

The Health, Environmental, and Regulatory Task Group (HERTG) of the American Chemistry Council Petroleum Additives Panel includes the following member companies:

Afton Chemical Corporation (formerly Ethyl Corporation)

Chevron Oronite Company, LLC

Crompton Corporation

ExxonMobil Chemical Company

Ferro Corporation

Infineum

The Lubrizol Corporation

Rhein Chemie Corporation

SNPE

EXECUTIVE SUMMARY

The American Chemistry Council Petroleum Additives Panel Health, Environmental, and Regulatory Task Group (HERTG), and its member companies, hereby submit for review and public comment its Final Submission for the *"petroleum additive alkaryl sulfonate"* category of chemicals under the Environmental Protection Agency's High Production Volume (HPV) Challenge Program. This Final Submission should be read in its entirety in order to obtain an understanding of the category and completed testing.

Petroleum Additive Alkaryl Sulfonate Category. Based on several factors specified in EPA's guidance document on "Development of Chemical Categories in the HPV Challenge Program," in which use of chemical categories is encouraged, the HERTG concluded the following twelve closely related chemicals constitute a chemical category:

- Sulfonic acids, petroleum, calcium salts - (CAS # 61789-86-4, referred to in this report as petroleum derived calcium salt)
- Sulfonic acids, petroleum, barium salts - (CAS # 61790-48-5, referred to in this report as petroleum derived barium salt)
- Sulfonic acids, petroleum, sodium salts - (CAS # 68608-26-4, referred to in this report as petroleum derived sodium salt)
- Sulfonic acids, petroleum, calcium salts, overbased - (CAS # 68783-96-0, referred to in this report as petroleum derived calcium salt, overbased)
- Benzenesulfonic acid, mono-C16-C24 alkyl derivatives, calcium salts - (CAS # 70024-69-0, referred to in this report as C16-C24 alkaryl calcium salt derivative)
- Benzenesulfonic acid, mono-C15-C30 branched alkyl and di-C11-C13 branched and linear alkyl derivatives, calcium salts, overbased - (CAS # 71486-79-8, referred to in this report as mixed mono-C15-C30 and di-C11-C13 alkaryl calcium salt, overbased derivative)
- Benzenesulfonic acid, mono-C15-C30 branched alkyl and di-C11-C13 branched and linear alkyl derivatives - (CAS # 71549-79-6, referred to in this report as mixed mono-C15-C30 and di-C11-C13 alkaryl derivative)
- Benzenesulfonic acid, mono and dialkyl derivatives, magnesium salts - (CAS # 71786-47-5, referred to in this report as alkaryl magnesium salt derivative)
- Benzenesulfonic acid, C15-C30 alkyl derivatives, sodium salts - (CAS # 78330-12-8, referred to in this report as C15-C30 alkaryl sodium salt derivative)
- Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives, calcium salts - (CAS # 115733-09-0, referred to in this report as C14-C24 alkaryl calcium salt derivative)
- Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives, calcium salts, overbased - (CAS # 115733-10-3, referred to in this report as C14-C24 alkaryl calcium salt, overbased derivative)
- Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives - (CAS # 115829-36-2, referred to in this report as C14-C24 alkaryl derivative)

Fate and Transport Characteristics. Based on their physicochemical properties and molecular structures, the HERTG concluded that these chemicals were most likely to adsorb strongly to soil and sediments. To verify this conclusion, the HERTG calculated fugacity data on a number of homologues of the alkaryl sulfonate category chemicals. Compounds in the group were highly hydrophobic such that hydrolysis testing was not technically feasible and the lack of hydrolysable moieties made hydrolysis modeling unnecessary. Two of the alkaryl sulfonates and one homologue were subjected to biodegradability testing and found to be poorly biodegradable. Computer modeled data indicated that the alkaryl sulfonates do not readily photodegrade.

Aquatic Toxicology. Existing data on acute fish toxicity, acute invertebrate toxicity, and alga toxicity were reviewed and the findings indicated a low order of toxicity to fish, aquatic invertebrates and alga when the appropriate test methods were used. Testing completed for this submission further confirmed that the chemical in this category possesses a low order of aquatic toxicity.

Mammalian Toxicology - Acute. Existing data on acute mammalian toxicity were reviewed and the findings indicated a low concern for acute toxicity. Data were available for most members of the category indicating that the category has been well tested for acute mammalian effects. Therefore, no additional acute mammalian toxicity testing was completed.

Mammalian Toxicology - Subchronic Toxicity. Existing data from repeated-dose toxicity studies were reviewed. Minimal signs of toxicity were observed following repeated oral exposure. Adverse effects at the site of contact were observed following repeated dermal exposure (injury to the skin) and repeated inhalation (injury to the lungs). An oral repeated-dose toxicity completed to support this submission confirmed that the alkaryl sulfonates possess a low order of repeat dose toxicity. These findings can be bridged to the remaining members of the category

Mammalian Toxicology - Reproductive and Developmental Toxicity. A one-generation reproductive toxicity test was conducted on one member of the category (CAS # 115733-09-0). Exposure to the alkaryl sulfonate did not significantly impact reproduction or development and these results were bridged to the remainder of the category.

Mammalian Toxicology - Mutagenicity. Existing data from bacterial reverse mutation assays and *in vitro* and *in vivo* chromosome aberration studies were reviewed and the findings indicated a low concern for mutagenicity. Data were available for several members of the category or structural analogs, and these data were bridged to the other members of the category. Therefore, the category has been adequately tested for mutagenicity and no additional testing was completed.

Conclusion. Based on the physiochemical, environmental fate, aquatic toxicology and mammalian toxicology studies completed for this submission and the data reviewed in this submission, the HERTG concluded that the petroleum additive alkaryl sulfonates do not pose a significant hazard to the aquatic and mammalian environments. As this final submission was completed, careful consideration was given to the number of animals required for tests and conditions to which the animals would be exposed. This resourceful use of existing and new data

has helped to minimize the use of animals for testing while effectively assessing the potential hazards of the category members.

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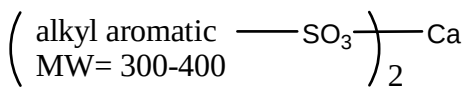
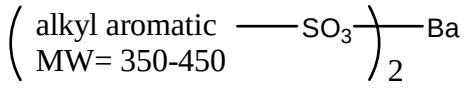
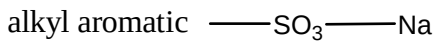
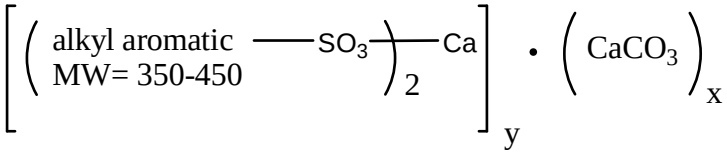
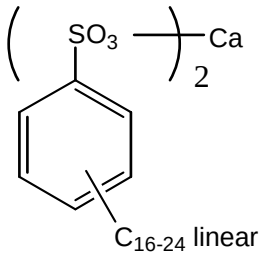
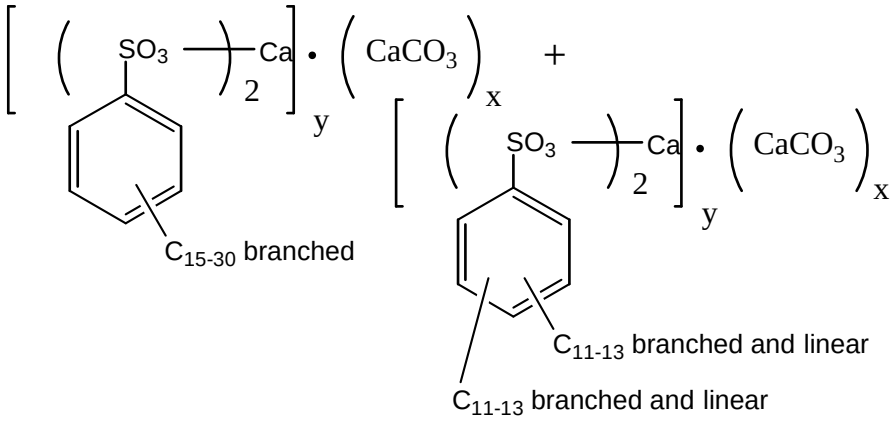
1.0 INTRODUCTION

In March 1999, the American Chemistry Council (formerly the Chemical Manufacturers Association) Petroleum Additives Panel Health, Environmental, and Regulatory Task Group (HERTG), and its participating member companies committed to address data needs for certain chemicals listed under the Environmental Protection Agency (EPA) High Production Volume (HPV) Chemical Challenge Program. This Final Submission follows up on that commitment. Specifically, this submission sets forth how the HERTG addressed information needs for the twelve petroleum additive alkaryl sulfonates substances shown in Tables 1 and 2.

TABLE 1. MEMBERS OF THE PETROLEUM ADDITIVE ALKARYL SULFONATE CATEGORY

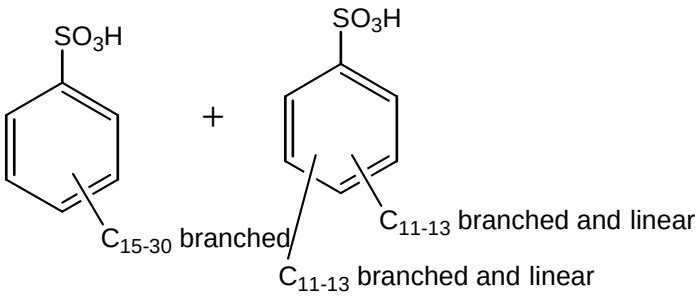
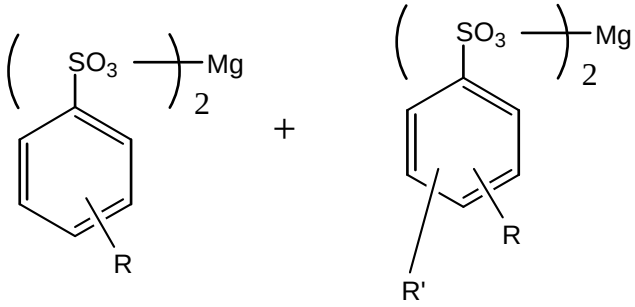
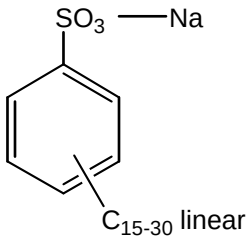
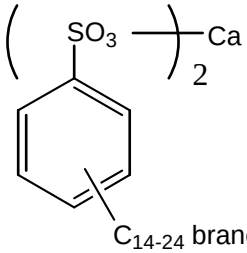
CAS Number	Chemical Name	Simplified Chemical Name
61789-86-4	Sulfonic acids, petroleum, calcium salts	Petroleum derived calcium salt
61790-48-5	Sulfonic acids, petroleum, barium salts	Petroleum derived barium salt
68608-26-4	Sulfonic acids, petroleum, sodium salts	Petroleum derived sodium salt
68783-96-0	Sulfonic acids, petroleum, calcium salts, overbased	Petroleum derived calcium salt, overbased
70024-69-0	Benzenesulfonic acid, mono-C16-C24 alkyl derivatives, calcium salts	C16-C24 alkaryl calcium salt derivative
71486-79-8	Benzenesulfonic acid, mono-C15-C30 branched alkyl and di-C11-C13 branched and linear alkyl derivatives, calcium salts, overbased	Mixed mono-C15-C30 and di-C11-C13 alkaryl calcium salt, overbased derivative
71549-79-6	Benzenesulfonic acid, mono-C15-C30 branched alkyl and di-C11-C13 branched and linear alkyl derivatives	Mixed mono-C15-C30 and di-C11-C13 alkaryl derivative
71786-47-5	Benzenesulfonic acid, mono and dialkyl derivatives, magnesium salts	Alkaryl magnesium salt derivative
78330-12-8	Benzenesulfonic acid, C15-C30 alkyl derivatives, sodium salts	C15-C30 alkaryl sodium salt derivative
115733-09-0	Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives, calcium salts	C14-C24 alkaryl calcium salt derivative
115733-10-3	Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives, calcium salts, overbased	C14-C24 alkaryl calcium salt, overbased derivative
115829-36-2	Benzenesulfonic acid, C14-C24 branched and linear alkyl derivatives	C14-C24 alkaryl derivative

TABLE 2. CHEMICAL STRUCTURES OF PETROLEUM ADDITIVE ALKARYL SULFONATES

CAS Number	Chemical Structure
61789-86-4	
61790-48-5	
68608-26-4	
68783-96-0	
70024-69-0	
71486-79-8	

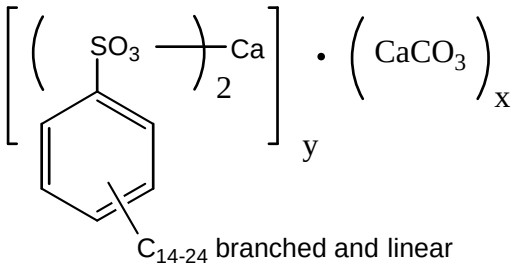
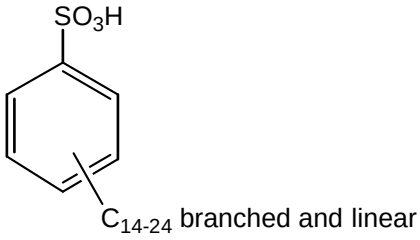
Typically, x = 10 -25 and y = 5 – 15

TABLE 2. CHEMICAL STRUCTURE S OF PETROLEUM ADDITIVE ALKYL SULFONATE (CONT.)

CAS Number	Chemical Structure
71549-79-6	
71786-47-5	 + the mixed mono and dialklybenzenesulfonic acid salts
78330-12-8	
115733-09-0	

Typically, x = 10 -25, y = 5 – 15, and R = C_{16} – C_{24}

TABLE 2. CHEMICAL STRUCTURE S OF PETROLEUM ADDITIVE ALKYL SULFONATE (CONT.)

CAS Number	Chemical Structure
115733-10-3	
115829-36-2	

Typically, x = 10 - 25 and y = 5 – 15

2.0 GENERAL SUBSTANCE INFORMATION

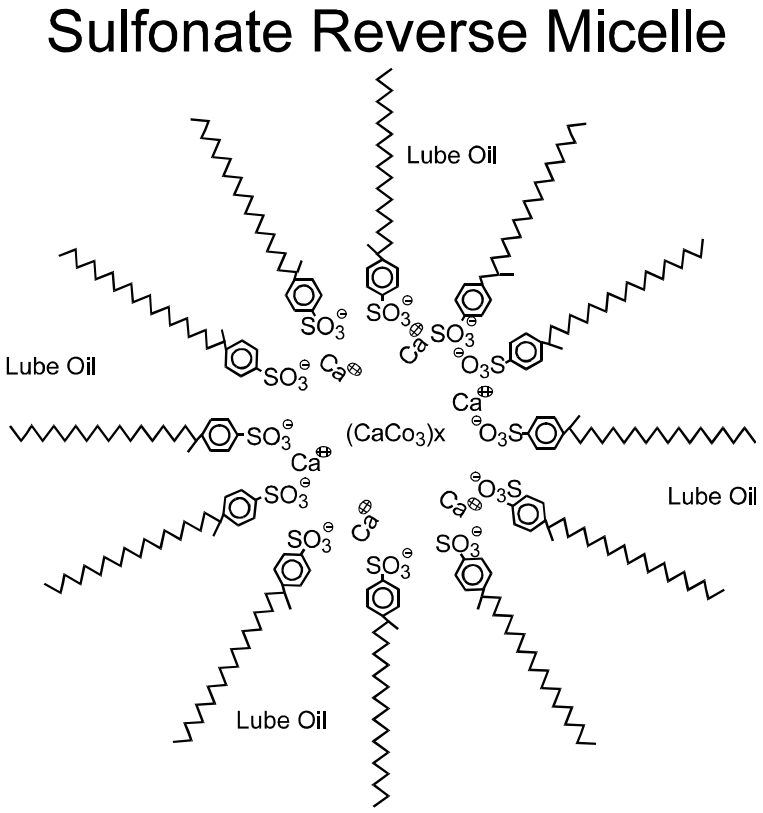
2.1 Manufacture

Petroleum additive alkaryl sulfonates are prepared by sulfonation of either synthetic alkylbenzene substrates or naturally occurring alkylaromatic-rich fractions of heavy lubricating oil base stocks derived from petroleum streams. The alkyl substituent group may vary in number (e.g., mono- or dialkyl), position (e.g., predominantly meta or para to the sulfonic acid position), chain length (e.g., C14 to C30) or in the degree of branching. Branched and linear alkyl groups of 20 or more carbons are used to enhance oil solubility. Although branched alkyl groups are generally presumed to be more water-soluble than straight chains, petroleum additive alkaryl sulfonates have such low water solubility that the degree of branching does not affect their solubility and performance in petroleum base stocks.

The petroleum additive alkaryl sulfonates are manufactured in highly refined lubricating base oil, and thus the substrates are never isolated. The sulfonic acid substituent group can be neutralized by alkali metal bases to form the corresponding alkali metal salt. For the members of the petroleum additive alkaryl sulfonate category, the sulfonic acid substituent group may be present as the free

acid or as a salt of sodium, calcium, magnesium or barium. The salts can also be complexed ("overbased") with an excess of metal carbonate. The overbased products are produced in the presence of the alkaryl sulfonic acid salt (soap) by adding excess metal hydroxide and carbon dioxide. The over basing reaction forms the metal carbonate which exists in the lubricating oil diluent as a reverse micelle (i.e., the metal carbonate is in the center of the micelle with the alkaryl sulfonic acid salt [soap] surrounding the carbonate). Figure 1 shows the general structure of a petroleum additive alkaryl sulfonate reverse micelle. The ratio of metal carbonate to soap can range from a low of 6:1 to a high of 30:1. As the ratio increases, the alkaryl sulfonic acid salt (soap) content is diluted. Thus, the overbased members of the category are considered more dilute analogs of the category members that are not overbased.

FIGURE 1. GENERAL STRUCTURE OF A PETROLEUM ADDITIVE ALKARYL SULFONATE REVERSE MICELLE



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2.2 Use

The alkaryl sulfonates that are the subject of this Final Submission are used as petroleum additives in petroleum base stocks. Petroleum additive alkaryl sulfonates are used to formulate finished lubricating oils including all types of automotive and diesel engine crankcase oils, air and water-cooled two-cycle engine oils, industrial oils, hydraulic fluids, gear oils and metal working lubricating oils. They are used as high temperature detergents to reduce deposits on pistons, engine crankcases, and hydraulic equipment parts and as rust inhibitors during industrial oil use. Petroleum additive alkaryl sulfonates are generally sold to finished oil blenders in additive packages, where the concentration ranges from 1 to 50 wt. %. These additive packages are then blended into finished oils where the typical concentration of alkaryl sulfonate ranges from 0.1 to 10 wt. % in the finished oil.

3.0 PHYSICOCHEMICAL PROPERTIES

The physicochemical properties of the members of the petroleum additive alkaryl sulfonate category are presented in Table 3. They are all dark colored viscous liquids at ambient temperature. The similarities in the other physicochemical properties of these substances, which are described below, are explained by similarities in their chemical structure and processing and provide justification of this group of chemicals as a category within the HPV Challenge Program.

TABLE 3. PHYSICOCHEMICAL PROPERTIES OF PETROLEUM ADDITIVE ALKARYL SULFONATES

CAS Number	Equivalent Weight[1]	Carbon Number Range	Specific Gravity[2] g/ml	Viscosity[3] cSt @ 100 °C	Melting Point[4] °C	Boiling Point[5] °C	Vapor Pressure[6] Pa	Water Solubility mg/L	Log Kow
115829-36-2	354-494	C14-C24	No data	No data	208.45	506.34	$<1X10^{-10}$	No data[7]	No data[7]
115733-09-0	393-533	C14-C24	No data	No data	349.84	935.88	$<1X10^{-10}$	0.479[8]	No data[7]
115733-10-3	393-533	C14-C24	No data	No data	349.84	935.88	$<1X10^{-10}$	No data[7]	No data[7]
68608-26-4	376-600	C14-C30	No data	No data	309.31	707.03	$<1X10^{-10}$	6.38[8]	No data[7]
61789-86-4	393-617	C14-C30	0.977	175	349.84	935.88	$<1X10^{-10}$	0.402[8]	No data[7]
68783-96-0	393-617	C14-C30	1.165	190	349.84	935.88	$<1X10^{-10}$	No data[7]	No data[7]
61790-48-5	490-714	C14-C30	No data	No data	349.84	935.88	$<1X10^{-10}$	1.03[8]	No data[7]
78330-12-8	390-600	C15-C30	No data	No data	347.25	788.26	$<1X10^{-10}$	38.2[8]	No data[7]
71549-79-6	368-578	C15-C30	No data	No data	208.45	506.34	$<1X10^{-10}$	0.075	>6.7
71486-79-8	407-617	C15-C30	No data	No data	341.76	776.50	$<1X10^{-10}$	No data[7]	No data[7]
70024-69-0	421-533	C16-C24	No data	No data	349.84	935.88	$<1X10^{-10}$	<0.100	>6.0
71786-47-5	461-517	C20-C24	1.142	225	349.84	935.88	$<1X10^{-10}$	No data[7]	No data[7]

[1]Equivalent weight = molecular weight of one alkylbenzene sulfonic acid plus molecular weight of metal.

[2]ASTM D1298-99, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

[3]ASTM D 445-97, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)

[4]Modeling data; melting point cannot be measured due to viscosity of liquid.

[5]Modeling data; boiling point cannot be determined because substance decomposes before it boils.

[6] "De-oiled" petroleum additive alkaryl sulfonates are solid. As manufactured, vapor pressure is estimated from the vapor pressure of the petroleum base stock in which the substance is manufactured.

[7]No data needed; bridging from other members of the category.

[8]Testing for water solubility conducted using the OECD 105 shake flask method.

4.0 ENVIRONMENTAL FATE DATA

4.1 Biodegradability

Two substances were evaluated for biodegradability under the conditions of the *Manometric Respirometry Test* (OECD Guideline 301F). In the 28-day test for the petroleum derived calcium salt (CAS # 61789-86-4), the extent of biodegradation was 8.6% based on theoretical oxygen demand (ThOD). For the mixed mono-C15-C30 and di-C11-C13 alkaryl calcium salt, overbased derivative (CAS # 71486-79-8), the extent of biodegradation in the 28-day test was 8.6% based on ThOD. A C20-C24 alkaryl calcium salt derivative (no CAS #), analog of the C16-C24 alkaryl sulfonate calcium salt (CAS # 70024-69-0), was evaluated for biodegradability under the conditions of the *Closed Bottle Test* (OECD Guideline 301D). In the 28-day test, the extent of biodegradability was 8% based on ThOD**.** An analog of the magnesium long-chain alkaryl sulfonate (CAS # 71786-47-5) exhibited 1.5 % biodegradation in 28 days in the modified sturm biodegradation test (OECD 301B). An analog of the calcium alkaryl sulfonate (CAS # 68783-96-0), had 9.1% biodegradation in 28 days (OECD 301B)

4.2 Hydrolysis

Since these substances do not contain functional groups that are susceptible to hydrolytic degradative mechanisms[1], testing these substances for hydrolysis as a function of pH is not needed to adequately evaluate this endpoint. Therefore, no hydrolysis testing was completed. **.**

4.3 Photodegradation

The tendency of these alkaryl sulfonates to photodegrade was evaluated by using the modeling program AOPWIN. This computer simulation of photo-oxidation was recommended in the Agency's recently released structure activity review (SAR) guidance for HPV chemicals. As shown in Table 4, the estimated photodegradation rate constants and half-lives of the alkaryl sulfonates indicate the members of the group do not readily photodegrade.

4.4 Fugacity Modeling

EQC Level 1 modeling (Mackay Equilibrium Criterion Model) was performed on the petroleum additive alkaryl sulfonates to support this Final Submission. The modeled data shown in Table 4 is representative of the lowest molecular weight free sulfonic acids for each material. The modeled fugacity results for the petroleum additive alkaryl sulfonates indicate these compounds will most likely strongly absorb to soil and sediments.

[1] W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt. (1982) Handbook of Chemical Property Estimation Methods. McGraw-Hill Book Co. New York, NY, USA.

TABLE 4. EVALUATION OF ENVIRONMENTAL FATE INFORMATION

CAS Number	BIODEGRADABILITY	HYDROLYSIS	PHOTODEGRADATION
	Available Data & Completed Testing	Available Data & Completed Testing	AOPWIN Model Estimation
115829-36-2	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 19.2 x 10^{-12} Half-life (hrs) = 6.69
115733-09-0	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 19.2 x 10^{-12} Half-life (hrs) = 6.69
115733-10-3	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 19.2 x 10^{-12} Half-life (hrs) = 6.69
68608-26-4	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 22.0 x 10^{-12} Half-life (hrs) = 5.83
61789-86-4	8.6% biodegraded after 28 days	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 22.0 x 10^{-12} Half-life (hrs) = 5.83
68783-96-0	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 22.0 x 10^{-12} Half-life (hrs) = 5.83
61790-48-5	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 22.0 x 10^{-12} Half-life (hrs) = 5.83
78330-12-8	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 19.2 x 10^{-12} Half-life (hrs) = 6.69
71549-79-6	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 28.9 x 10^{-12} Half-life (hrs) = 4.44
71486-79-8	8.6% biodegraded after 28 days	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 28.9 x 10^{-12} Half-life (hrs) = 4.44
70024-69-0	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 22.0 x 10^{-12} Half-life (hrs) = 5.83
C20-C24 analog of 70024-69-0	8.0% biodegraded after 28 days	No testing needed for analogs	No estimation needed for analogs
71786-47-5	No testing needed Bridging	No testing needed[1]	OH^- Rate Constant (cm^3/molec-sec) = 28.9 x 10^{-12} Half-life (hrs) = 4.44
Analog of 71786-47-5	1.5 % biodegraded after 28 days	Not testing needed for analogs	No estimation needed for analogs
Analog of 68783-96-0	9.1 % biodegraded after 28 days	Not testing needed for analogs	No estimation needed for analogs

[1]See technical discussion of information presented in Table 5.

TABLE 5. FUNCTIONAL GROUP, CHEMICAL CLASSES, AND HYDROLYTIC POTENTIAL OF PETROLEUM ADDITIVE ALKARYL SULFONATES

CAS Number	Functional Group and Chemical Class	Potential for Hydrolysis
115829-36-2 115733-09-0 115733-10-3	Aromatic benzene ring Branched hydrocarbon chain Linear hydrocarbon chain Sulfonic acid	Low Low Low Low
68608-26-4 61789-86-4 68783-96-0 61790-48-5	Aromatic benzene ring Branched hydrocarbon chain Linear hydrocarbon chain Sulfonic acid	Low Low Low Low
78330-12-8	Aromatic benzene ring Linear hydrocarbon chain Sulfonic acid	Low Low Low
71549-79-6 71486-79-8	Aromatic benzene ring Branched hydrocarbon chain Linear hydrocarbon chain Sulfonic acid	Low Low Low Low
70024-69-0	Aromatic benzene ring Linear hydrocarbon chain Sulfonic acid	Low Low Low
71786-47-5	Aromatic benzene ring Branched hydrocarbon chain Linear hydrocarbon chain Sulfonic acid	Low Low Low Low

5.0 ECOTOXICOLOGY DATA

5.1 Acute Fish Toxicity

Six of the twelve substances in the category and one structural analog were evaluated for acute toxicity to fish in five studies. Maximum test material loading rates were either 100, 1,000 or 10,000 mg/L. No mortality was observed in any of the studies. Overall, the LL_{50} for these substances was greater than 100 mg/L indicating a relatively low order of acute toxicity to fish.

5.2 Acute Invertebrate Toxicity

Five of the twelve substances in the category were evaluated for acute toxicity to daphnids. The maximum test material loading rate was 100 or 1,000 mg/L. In general, minimal effects were observed in the studies. Overall, the EL_{50} for these substances was greater than 100 mg/L indicating a relatively low order of acute toxicity to daphnids.

5.3 Alga Toxicity

Five of the twelve substances in the category were evaluated for algal growth inhibition. Maximum test material loading rates were either 100, 1,000 or 1,500 mg/L. The results indicate no observed toxicity to algae at 100 mg/L. Overall, the EL_{50} for these substances was greater than 100 mg/L indicating a relatively low order of toxicity to algae.

TABLE 6. EVALUATION OF AQUATIC TOXICOLOGY INFORMATION

CAS Number	ACUTE TOXICITY TO FISH 96-hr LL_{50} (mg/L)[1]	ACUTE TOXICITY TO INVERTEBRATES 48-hr EL_{50} (mg/L)[1]	TOXICITY TO ALGAE 96-hr EL_{50} (mg/L)[1]
	Available Data & Completed Testing	**Available Data & Completed Testing**	**Available Data & Completed Testing**
115829-36-2	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging
115733-09-0	> 100 (WAF, T)	>1,000 (WAF[3], D)	>1,000 (WAF[3], P, R) >1,000 (WAF[3], P, B)
115733-10-3	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging
68608-26-4	> 100 (WAF, T)	> 100 (WAF[3], D)	> 100 (WAF[3], G, R)
61789-86-4	> 100 (WAF, T) >10,000 (WAF[2], S)	> 100 (WAF[3], D)	> 100 (WAF[3], G, R)
68783-96-0	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging
61790-48-5	> 100 (WAF, T)	No testing needed Bridging	No testing needed Bridging
78330-12-8	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging

[1]Toxicity endpoints are expressed as median lethal loading rates (LL_{50}) for fish and median effective loading rates (EL_{50}) for *Daphnia* and algae. The EL/LL_{50} is defined as the loading rate that adversely affects 50% of the test organisms exposed over a specific time. The greater the EL/LL_{50} the lower the toxicity.
[2]WAF = Water accommodated fraction static renewal test.
[3]WAF = Water accommodated fraction static non-renewal test.
[4]EL/LL_0 = no mortality or effects observed at the highest loading rate tested.
B = algae biomass.
D = freshwater cladoceran, *Daphnia magna*.
F = fathead minnow, *Pimephales promelas*.
G = green algae, *Scenedesmus subspicatus*
P = freshwater algae *Pseudokirchneriella subcapitata* formerly called *Selenastrum capricornutum*.
R = algae growth rate.
S = sheepshead minnow, *Cyprinodon variegatus*.
T = rainbow trout, *Oncorhynchus mykiss* formerly called *Salmo gairdneri.*

TABLE 6. EVALUATION OF AQUATIC TOXICOLOGY INFORMATION (CONT.)

CAS Number	ACUTE TOXICITY TO FISH 96-hr LL_{50} (mg/L)[1]	ACUTE TOXICITY TO INVERTEBRATES 48-hr EL_{50} (mg/L)[1]	TOXICITY TO ALGAE 96-hr EL_{50} (mg/L)[1]
	Available Data & Completed Testing	**Available Data & Completed Testing**	**Available Data & Completed Testing**
71549-79-6	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging
71486-79-8	>1,000 (WAF[2], F)	>1,000 (WAF[3], D)	>1,000 (WAF[3], P, R) >1,000 (WAF[3], P, B)
70024-69-0	No testing needed Bridging	No testing needed Bridging	No testing needed Bridging
70024-71-4 C20-C24 analog of 70024-69-0	>10,000 (WAF[2], S)	No testing needed	No testing needed
71786-47-5	>1,000 (WAF[2], F) >10,000 (WAF[2], S)	>1,000 (WAF[3], D)	>1,000 (WAF[3], P, R) >1,000 (WAF[3], P, B)

[1]Toxicity endpoints are expressed as median lethal loading rates (LL_{50}) for fish and median effective loading rates (EL_{50}) for *Daphnia* and algae. The EL/LL_{50} is defined as the loading rate that adversely affects 50% of the test organisms exposed over a specific time. The greater the EL/LL_{50} the lower the toxicity.
[2]WAF = Water accommodated fraction static renewal test.
[3]WAF = Water accommodated fraction static non-renewal test.
[4]EL/LL_0 = no mortality or effects observed at the highest loading rate tested.
F = fathead minnow, *Pimephales promelas*.
D = freshwater cladoceran, *Daphnia magna*.
P = freshwater algae *Pseudokirchneriella subcapitata* formerly called *Selenastrum capricornutum*.
T = rainbow trout, *Oncorhynchus mykiss* formerly called *Salmo gairdneri.*
S = sheepshead minnow, *Cyprinodon variegatus*.
R = algae growth rate.
B = algae biomass.

6.0 MAMMALIAN TOXICOLOGY DATA

6.1 Acute Mammalian Toxicity

6.1.1 ACUTE ORAL TOXICITY

Eight of the twelve substances in the petroleum additive alkaryl sulfonate category and a C20-C24 alkaryl calcium salt derivative (no CAS #), analogs of the C16-C24 alkaryl calcium salt (CAS # 70024-69-0) and the C15-C30 alkaryl sodium salt derivative (CAS # 78330-12-8), have been adequately tested for acute oral toxicity (OECD Guideline 401, *Acute Oral Toxicity*). In all but one of these studies, there were no deaths that could be attributed to treatment with the test material when administered at the limit dose of 2000 or 5000 mg/kg. In some studies, the primary clinical observations were diarrhea and reduced food consumption (without a change in body weight). These effects are consistent with the gastrointestinal irritant properties of detergents in an oil-based vehicle. In other studies, decreased body weight gain or ruffled fur was observed. In one study where deaths occurred, animals were administered dose levels well above the 2000 mg/kg limit dose. Overall, the acute oral LD_{50} for these substances was greater than the 2000 mg/kg limit dose indicating a relatively low order of toxicity.

6.1.2 ACUTE DERMAL TOXICITY

Three of the twelve substances in the petroleum additive alkaryl sulfonate category and a C20-C24 alkaryl calcium salt derivative (no CAS #), analog of the C16-C24 alkaryl calcium salt (CAS # 70024-69-0); have been adequately tested for acute dermal toxicity (OECD Guideline 402, *Acute Dermal Toxicity*). No mortality was observed for any substance when administered at the limit dose of 2000 or 5000 mg/kg. The principal clinical observation was erythema and/or edema at the site of dermal application. In some cases, the cutaneous findings included dry, flaky skin, desquamation and hyperkeratosis. Overall, the acute dermal LD_{50} for these substances was greater than the 2000 mg/kg limit dose indicating a relatively low order of toxicity.

6.1.3 ACUTE INHALATION TOXICITY

One member of the petroleum additive alkaryl sulfonate category (CAS# 68783-96-0) was tested for acute inhalation toxicity (OECD Guideline 403, *Acute Inhalation Toxicity*). Rats were exposed whole-body to an aerosol of the substance at a nominal atmospheric concentration of 1.9 mg/L for four hours. This was the maximum attainable concentration due to the low volatility and high viscosity of the test material. No mortality was noted, and all animals fully recovered following depuration. Clinical signs of toxicity during exposure included reduced activity, matted coat, and closed eyes. Clinical signs of toxicity

observed post exposure included lacrimation, nasal discharge, salivation rates, matted coat, hunched appearance, soft stools and closed eyes. No treatment-related macroscopic findings were noted. The lack of mortality at a concentration just below the limit dose of 2.0 mg/L indicates a relatively low order of toxicity for this substance.

TABLE 7. EVALUATION OF ACUTE MAMMALIAN TOXICOLOGY

CAS Number	ACUTE ORAL TOXICITY[1] Available Data & Completed Testing	ACUTE DERMAL TOXICITY[1] Available Data & Completed Testing
115829-36-2	No testing needed Bridging	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
115733-09-0	LD_{50} > 5.0 g/kg (rat)	LD_{50} >5.0 g/kg (rabbit)
115733-10-3	No testing needed Bridging	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
68608-26-4	LD_{50} > 5.0 g/kg (rat)	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
61789-86-4	LD_{50} > 5.0 g/kg (rat)	LD_{50} > 5.0 g/kg (rabbit)
68783-96-0	LD_{50} > 5.0 g/kg (rat)	LD_{50} > 2.0 g/kg (rabbit)
61790-48-5	LD_{50} > 2.0 g/kg (rat)	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
78330-12-8	No testing needed Bridging	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
71549-79-6	LD_{50} = 14.9g/kg (rat)	No testing needed Acute toxicity end point satisfied by acute oral toxicity results

[1]Toxicity endpoints are expressed as median lethal dose (LD_{50}) for acute oral and dermal toxicity and median lethal concentration (LC_{50}) for acute inhalation toxicity. The LD/LC_{50} is defined as the dose/concentration that is lethal to 50% of the test organisms. The greater the LD/LC_{50}, the lower the toxicity.
[2]LC_0 = no mortality observed at the highest concentration tested.

TABLE 7. EVALUATION OF ACUTE MAMMALIAN TOXICOLOGY (CONT.)

CAS Number	ACUTE ORAL TOXICITY[1]	ACUTE DERMAL TOXICITY[1]
	Available Data & Completed Testing	Available Data & Completed Testing
71486-79-8	No testing needed Bridging	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
70024-69-0	No testing needed Bridging	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
C20-C24 alkaryl calcium salt (no CAS #) analog of 70024-69-0	LD_{50} > 5.0 g/kg (rat)	LD_{50} > 2.0 g/kg (rat)
71786-47-5	LD_{50} > 16.0 g/kg (rat)	No testing needed Acute toxicity end point satisfied by acute oral toxicity results
Analog of 78330-12-8	LD_{50} > 5.0 g/kg (rat)	No testing needed on analogs

[1]Toxicity endpoints are expressed as median lethal dose (LD_{50}) for acute oral and dermal toxicity and median lethal concentration (LC_{50}) for acute inhalation toxicity. The LD/LC_{50} is defined as the dose/concentration that is lethal to 50% of the test organisms. The greater the LD/LC_{50}, the lower the toxicity.
[2]LC_0 = no mortality observed at the highest concentration tested.

6.2 Repeated-dose Toxicity

6.2.1 SYSTEMIC TOXICITY TESTS

Three of the 12 substances in the alkaryl sulfonate category and a structural analog have been tested for subchronic toxicity in five studies.

The petroleum derived calcium salt, overbased (CAS # 68783-96-0) was evaluated in a 28-day repeated-dose dermal toxicity study in rats (OECD Guideline 410). A low incidence of erythema, desquamation and scabbing was sporadically observed in treated animals. The NOAEL for systemic toxicity for this study was 1000 mg/kg/day (highest dose). The petroleum derived calcium salt, overbased (CAS # 68783-96-0) was also evaluated in a 28-day inhalation toxicity study in rats (OECD Guideline 412, *Repeated Dose Inhalation Toxicity: 28/14 Day*). Inhalation exposures were six hours/day, five days/week for four weeks at actual whole-body exposure concentrations of 49.5, 156 and 260 mg/m^3. The experimental animals were observed to have red nasal discharge, matted coat and decreased activity at the two highest dose levels. Dose-related increases in lung weight were accompanied by microscopic evidence of intralobular macrophage accumulation and bronchiole epithelial hyperplasia/hypertrophy. Based on the latter findings, the NOAEL was 49.5 mg/m^3.

A C20-C24 alkaryl calcium salt derivative (no CAS #), analog of C16-C24 alkaryl calcium salt derivative (CAS # 70024-69-0), was evaluated in a 28-day repeated-dose oral toxicity study in rats (OECD Guideline 407). The substance was administered at 100, 500 and 1000 mg/kg/day for 28 consecutive days. Serum chemistry analysis revealed significant reductions in cholesterol in the high dose male and female groups. Based on the reduction in mean serum cholesterol, the NOAEL was 500 mg/kg/day.

The alkaryl magnesium salt derivative (CAS # 71786-47-5) was evaluated in a 28-day repeated-dose dermal toxicity study in rats (OECD Guideline 410). The substance was applied topically at doses of 100, 300 or 1000 mg/kg under occlusive dressing six hours/day for 28 consecutive days. Local cutaneous responses, characterized by desquamation and hyperkeratosis were seen in some rats. The NOAEL for systemic toxicity for this study was 1000 mg/kg/day (highest dose).

The alkaryl magnesium salt derivative (CAS # 71786-47-5) was also evaluated in a 28-day repeated-dose dermal toxicity study in rabbits (OECD Guideline 410). The substance was applied topically at a dose volume of 2 ml/kg/day and concentrations of 0, 25, or 100% (w/v) in Primol 205 for six hours/day, five days/week for 20 days. Systemic findings included significant reductions in hematological parameters (hemoglobin, hematocrit, erythrocyte count and leukocyte count) in the high dose group. A reduction in total plasma protein

(including globulin) and increases in serum alkaline phosphatase, SGPT, and SGOT levels were observed in both treatment groups. Elevations in the serum levels of hepatic enzymes were accompanied by increases in liver weights in both treatment groups, but histopathological lesions (multifocal hepatocellular degeneration) were observed only in the high dose group. Testes and epididymides weights were also reduced in both treatment groups. Changes in male reproductive organs in the rabbit have been observed when other irritating substances are applied to the skin at dose levels that cause skin lesions.[2,3] Thus, dermal irritation alone, or in combination with the accompanying weight loss and stress, is thought to play a role in the reproductive organ response to repeated cutaneous application of zinc dialkyldithiophosphates. Microscopic changes observed in the high dose group included aspermatogenesis and multifocal tubular hypoplasia in the testes and epithelial hypoplasia in the epididymides. Due to the observation of adverse effects at both dose levels, an NOAEL was not established in this study.

An oral 28-day repeat dose study was conducted on the C14-C24 alkaryl calcium salt derivative (CAS # 115733-09-0). Male and female rats were administered 50, 150, 500, or 1000 mg/kg CAS # 115733-09-0. The most notable lesion in males given 500 or 1000 mg/kg/day was mild irritation in the nonglandular portion of the stomach. Because of the mild nature of the stomach irritation, the NOAEL for males was determined to be 1000 mg/kg/day. However, for females, there was one 500 mg/kg/day female that had a stomach ulcer with inflammation, hyperplasia, hemorrhage and edema. Therefore, the NOAEL for females was determined to be 150 mg/kg/day.

6.2.2 REPRODUCTIVE/DEVELOPMENTAL TOXICITY

An oral one-generation reproduction toxicity study (OECD 415) was conducted on the C14-C24 alkaryl calcium salt derivative (CAS # 115733-09-0). Parental male and female rats were administered 50, 167, or 500 mg/kg CAS # 115733-09-0. The most remarkable findings noted during this study, included a slight, but dose-responsive increase in post-dose observations of salivation and dark material around the nose for the F0 males. The differences in the remaining parameters evaluated for the F0 males, F0 females and F1 pups were not considered toxicologically meaningful, since there was no consistent pattern that could be attributed to treatment. Some of these parameters included F0 survival and clinical observations; F0 mean body weight, body weight change and food consumption; F0 reproductive indices and F1 pup viability and body weights; F0 male and female gross necropsy findings; F0 male and female absolute organ weight and organ to body weight ratio; F0 male semen analysis; F1 pup clinical observations and F1 pup necropsy findings. From these results, a NOAEL for F0

[2] Wong, Z.A., VonBurg, R., Spangler, W.L., and MacGregor, J.A. (1982) Testicular Damage in the Rabbit Resulting from Simple Chemical Cutaneous Irritation. The Toxicologist 2:41.
[3] McKee, R.H., Kapp, Jr., R.W., and Ward, D.P. (1985) Evaluation of the Systemic Toxicity of Coal Liquefaction Derived Materials Following Repeated Dermal Exposure in the Rabbit. J. App. Toxicol. 5: 345-351.

and F1 rats was determined to be 500mg/kg/day. Therefore, there was not a test article related effect on reproduction or development in rats exposed to CAS # 115733-09-0. These results were bridged to other compounds in the group.

TABLE 9. EVALUATION OF REPEATED-DOSE MAMMALIAN TOXICOLOGY

CAS Number	REPEATED-DOSE TOXICITY Available Data & Completed Testing	REPRODUCTIVE/DEVELOPMENTAL TOXICITY Available Data & Completed Testing
115829-36-2	No testing needed Bridging	No testing needed Bridging
115733-09-0	**28-day oral repeat dose study in rats (OECD 407)** NOAEL males = 1000 mg/kg NOAEL females = 150 mg/kg (stomach irritation) No other significant effects either sex	**Oral 1-generation reproduction study in rats (OECD 415)** NOAEL = 500 mg/kg highest dose (for F_0 and F_1 generations) CAS # 15733-09-0 administration did not consistently affect any reproductive/developmental endpoint
115733-10-3	No testing needed Bridging	No testing needed Bridging
68608-26-4	No testing needed Bridging	No testing needed Bridging
61789-86-4	No testing needed Bridging	No testing needed Bridging
68783-96-0	**28-day repeated-dose dermal study in rats (OECD 410)** NOAEL = 1000 mg/kg/day (highest dose tested) **28-day inhalation study in rats (OECD 412)** NOAEL = 49.5 mg/m^3 At 260 mg/m^3, • signs of toxicity (decreased body weight gain (males), increased lung weights, intra-alveolar microphage accumulation, bronchiole epithelium hyperplasia/hypertrophy; At 156 mg/m^3, • signs of toxicity (increased lung weights, intra-alveolar microphage accumulation, bronchiole epithelium hyperplasia/hypertrophy; At 49.5 mg/m^3, • no significant effects.	No testing needed Bridging

TABLE 9. EVALUATION OF REPEATED-DOSE MAMMALIAN TOXICOLOGY (CONT.)

CAS Number	REPEATED-DOSE TOXICITY Available Data & Completed Testing	REPRODUCTIVE/DEVELOPMENTAL TOXICITY Available Data & Completed Testing
61790-48-5	No testing needed Bridging	No testing needed Bridging
78330-12-8	No testing needed Bridging	No testing needed Bridging
71549-79-6	No testing needed Bridging	No testing needed Bridging
71486-79-8	No testing needed Bridging	No testing needed Bridging
70024-69-0	No testing needed Bridging	No testing needed Bridging
C20-C24 alkaryl calcium salt (no CAS #) analog of 70024-69-0	**4-week repeated-dose oral study in rats (OECD 407)** NOAEL = 500 mg/kg/day At 1000 mg/kg/day, • decreased serum cholesterol; At 500 mg/kg/day, • no significant effects; At 100 mg/kg/day, • no significant effects.	No testing needed Bridging

TABLE 9. EVALUATION OF REPEATED-DOSE MAMMALIAN TOXICOLOGY (CONT.)

CAS Number	REPEATED-DOSE TOXICITY Available Data & Completed Testing	REPRODUCTIVE/DEVELOPMENTAL TOXICITY Available Data & Completed Testing
71786-47-5	**28-day repeated dose dermal study in rats (OECD 410)** NOAEL = 1000 mg/kg/day (highest dose tested). **28-day repeated dose dermal study in rabbits (OECD 410)** <u>At 2.0 ml/kg/day,</u> • two males sacrificed in moribund condition; • decreased mean body weight; • alopecia and erythema, edema, atonia, desquamation, fissuring, and exfoliation of the skin; • decreased total leukocyte count; • decreased red blood cell count, hemoglobin, and hematocrit, (females only); • decreased total serum protein and serum globulin; • increased SGOT and serum alkaline phosphatase (males); • increased SGOT and SGPT (females); • increased liver weights and focal hepatocellular degeneration, necrosis, and vacuolation; • decreased testes weights with aspermatogenesis, decreased number of spermatids and diffuse tubular hypoplasia; • decreased epididymides weights with epithelial hypoplasia; <u>At 0.5 ml/kg/day,</u> • alopecia and erythema, edema, atonia, desquamation, fissuring, and exfoliation of the skin; • decreased total leukocyte count; • decreased total serum protein and serum globulin; • increased SGOT and serum alkaline phosphatase (males); • increased SGOT and SGPT (females); • increased liver weights; • decreased testes and epididymides weights.	No testing needed Bridging

6.3 Genotoxicity

6.3.1 Bacterial Gene Mutation Assay

Two of the twelve substances in this category and two structural analogs, a C20-C24 alkaryl calcium salt derivative (no CAS #), analog of the C16-C24 alkaryl calcium salt (CAS # 70024-69-0), and a C15-C21 alkaryl sodium salt derivative (no CAS #), analog of C15-C30 alkaryl sodium salt derivative (CAS # 78330-12-8), have been adequately tested in a *Bacterial Reverse Mutation Test* (OECD Guidelines 471 and/or 472). All tested substances were negative for mutagenic activity, with and without metabolic activation.

6.3.2 Mammalian Gene Mutation Assay

One substance in this category has been adequately tested in a mouse lymphoma cell assay (OECD Guideline 476, *In Vitro Mammalian Cell Gene Mutation Test*). The results of this study were negative for mutagenic activity with and without metabolic activation of the test substance.

6.3.3 *In vivo* Chromosomal Aberration Assays

Two of the twelve substances in this category and a C20-C24 alkaryl calcium salt derivative (no CAS #) analog of the C16-C24 alkaryl calcium salt (CAS # 70024-69-0) have been adequately tested in an *in vivo* chromosomal aberration assay. These studies were conducted using bone marrow cells from mice that were dosed by oral gavage or intraperitoneal injection (OECD Guideline 474, *Mammalian Erythrocyte Micronucleus Test*). All test substances were negative for clastogenicity.

6.3.4 *In vitro* Chromosomal Aberration Assay

Two substances have been adequately tested in an *in vitro* chromosomal aberration assay using Chinese hamster ovary cells (OECD Guideline 473, *In Vitro Mammalian Chromosome Aberration Test*). The results of these studies, performed with and without metabolic activation of the test material, were negative for clastogenicity.

TABLE 8. EVALUATION OF GENOTOXICITY INFORMATION

CAS Number	GENE MUTATION ASSAY Available Data & Proposed Testing	CHROMOSOMAL ABERRATION ASSAY Available Data & Proposed Testing
115829-36-2	No testing needed Bridging	No testing needed Bridging
115733-09-0	No testing needed Bridging	No testing needed Bridging
115733-10-3	No testing needed Bridging	No testing needed Bridging
68608-26-4	No testing needed Bridging	No testing needed Bridging
61789-86-4	No testing needed Bridging	No testing needed Bridging
68783-96-0	Bacterial Reverse Mutation Assay – Not mutagenic Mouse Lymphoma Mutagenicity Screen – Not mutagenic	Mouse Micronucleus Assay – Not clastogenic *In vitro* CHO Cell Chromosomal Aberration Assay – Not clastogenic
61790-48-5	No testing needed Bridging	No testing needed Bridging
C15-C21 alkaryl sodium salt (no CAS #) analog of 78330-12-8	Bacterial Reverse Mutation Assay – Not mutagenic	No testing needed Bridging
78330-12-8	No testing needed Bridging	No testing needed Bridging
71549-79-6	No testing needed Bridging	No testing needed Bridging
71486-79-8	No testing needed Bridging	No testing needed Bridging

TABLE 8. EVALUATION OF GENOTOXICITY INFORMATION

CAS Number	GENE MUTATION ASSAY	CHROMOSOMAL ABERRATION ASSAY
	Available Data & Proposed Testing	**Available Data & Proposed Testing**
70024-69-0	No testing needed Bridging	No testing needed Bridging
C20-C24 alkaryl calcium salt (no CAS #) analog of 70024-69-0	Bacterial Reverse Mutation Assay – Not mutagenic	Mouse Micronucleus Assay – Not clastogenic
71786-47-5	Bacterial Reverse Mutation Assay – Not mutagenic	Mouse Micronucleus Assay – Not clastogenic *In vitro* CHO Cell Chromosomal Aberration Assay – Not clastogenic